

RESERVE

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COMPLETE SPECIFICATION.

Improvements in or relating to Fluid Contactor Apparatus.

We, UNITED KINGDOM ATOMIC ENERGY AUTHORITY, of London, a British Authority, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement :—

This invention relates to liquid-liquid contactor apparatus of a type comprising a cylindrical column mounted coaxially and adapted to rotate within a cylindrical vessel.

An apparatus of this type has been described by Sir Geoffrey Taylor in the Transactions of the Philosophical Society 1923, Vo. 223A, p.289. As the inner column is rotated a series of oppositely rotating toroidal vortices one above the other are set up in a liquid in the annular space between the columns. When used for contacting two liquids the vortices are set up in the continuous phase at very low speeds and as the speed is increased the dispersed phase becomes broken up by the shearing action into droplets small enough for them to be carried into the vortices.

In small scale laboratory apparatus the vortices are approximately circular in cross-section and are packed closely together. The efficiency of a column of given height or its number of equivalent theoretical stages is related to the number of vortex pairs and this number is a maximum when the vortices are arranged in a close pattern as in the said small scale apparatus.

It is found, however, that approximately circular section vortices are formed only if the width of the annulus in the radial direction is more than one half the radius of the inner member. When scaled up to form part of a production plant the retention of these proportions means that the vortices assume large dimensions and for a given number of equivalent theoretical plates a column of considerable height is required.

If, in an attempt to produce smaller vortices, the width of the annulus is reduced so that it is a small fraction of the radius of the inner member, the vortices, instead of remaining circular, tend to elongate in the vertical direction, their height becoming several times their radial width, and no advantage in respect of a reduction in height of the column is obtained.

We have discovered that it is possible to control the vortex pattern so as to reduce the height of the vortices and to this end according to the invention a plurality of annular fins are provided on the rotor such that two contra-rotating vortices are contained within each pair of fins.

It is known to mount a number of disc-shaped baffles on a shaft mounted coaxially in a liquid-liquid contactor column so that when the shaft is rotated a powerful centrifugal pumping action is set up which, in conjunction with annular baffles fixed to the inside of the column, produces a series of outward followed by inward radial flow paths in succession down the column between the baffles.

The present invention is, however, concerned only with apparatus of the type set forth in which the radial dimension of the rotor is such that contra-rotating vortices are set up by the motion of the rotor itself in the absence of fins or baffles.

In any such system comprising an inner rotating column the invention may be applied to reduce the height of the vortices even if they are normally of circular section but the invention is of the greatest advantage when the relative dimensions are, as stated above, such that tall elongated vortices would be produced in the absence of control. Hence the invention is of particular application when the annular space has a radial dimension less than half the radius of the rotor in which case the fins may be spaced apart

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along the rotor approximately twice the radial dimension of the annular space.

A small scale production column in accordance with the invention will now be described by way of example with reference to the accompanying drawing which is a vertical cross-section of the apparatus. The column is designed to extract a solute from an aqueous solution by means of an organic solvent and comprises an inner stainless steel cylinder or rotor 1 suspended from a vertical shaft 2 mounted in substantial bearings 3 and arranged to be driven by a belt drive on to a pulley 4 by an electric motor such that the cylinder 1 rotates slowly about its axis. The cylinder 1 is $5\frac{1}{2}$ in. diameter and carries 18 annular fins 5 spaced about 1 in. apart and projecting $\frac{3}{8}$ in. from its surface.

The outer cylinder or stator 6 is a cylindrical glass vessel $6\frac{1}{2}$ in. internal diameter and somewhat longer than the rotor 1. The bottom of the vessel 6 is rounded and provided with an outlet 7 at its lowest point for the aqueous raffinate. This non-cylindrical bottom part is "blanked-off" by a loose fitting lead filled polythene plug 8 having a flat upper surface which is about 1 cm. below the bottom of the rotor 1.

A polythene cover 9 closes the top of the vessel and supports a polythene baffle 10 just above the top of the rotor 1.

The aqueous feed is taken in through a polythene tube 11 to a point just below the baffle 10. As stated above the aqueous raffinate is removed from the lowest point of the vessel through the outlet 7. The solvent feed is taken from a connection 12 on a manifold 13 to four spaced inlets 14 level with the bottom of the rotor 1 and the solvent outlet is by suction through a polythene tube 15 from the highest part of the vessel 6.

In the operation of the apparatus large drops of the solvent entering through the inlets 14 are subjected to a shearing stress and break up into small droplets small enough to be carried into the vortices. In the column as a whole the two liquids move in counter current direction passing the edges

of the fins from one vortex system to another to do so. The maximum flow rate is thus largely determined by the clearance between the fins and the stator which clearance may vary within wide limits so long as pairs of contra-rotating vortices are sustained between each pair of fins.

The optimum peripheral velocity depends on the viscosity and inter-facial tension of the particular liquids used and can be readily determined by trial. For extraction from aqueous solution by organic solvents in an apparatus of the size above described high extraction rates were obtained over a range of speeds from 110 to 300 r.p.m. according to the particular solutions and solvents. With one particular system five theoretical stages were obtained in the apparatus described.

What we claim is:—

1. In a liquid-liquid contactor apparatus comprising a cylindrical vessel, a cylindrical rotor mounted coaxially within said vessel such that pairs of contra-rotating vortices are set up in a liquid contained between the rotor and the wall of the vessel when the rotor is turned, the provision of a pair of annular radial fins on the rotor for controlling the vertical dimensions of each vortex pair.

2. A liquid-liquid contactor apparatus comprising a cylindrical containing vessel, a cylindrical rotor mounted for rotation coaxially within said vessel to leave an annular space having a radial dimension less than half the radius of the rotor, a plurality of annular fins on said rotor spaced apart along the rotor approximately twice said radial dimension so as to confine between each pair two contra-rotating substantially circular vortices, conduit means for feeding the liquids to be contacted to the vessel and conduit means for removing the extract and the raffinate.

3. A liquid-liquid contactor apparatus substantially as described with reference to the accompanying drawing.

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PROVISIONAL SPECIFICATION.

Improvements in or relating to Fluid Contactor Apparatus.

95 We, UNITED KINGDOM ATOMIC ENERGY AUTHORITY, of London, a British Authority, do hereby declare this invention to be described in the following statement:—

100 This invention relates to fluid contactor apparatus of a type comprising inner and outer columns having relative rotation.

In such apparatus the dispersed phase appears to exist in the column as a series of oppositely rotating toroidal vortices one

above the other which fill the annular space between the cylinders. In small scale laboratory apparatus these vortices are circular in cross-section and are packed closely together. The efficiency of the column or its "number of theoretical plates" is found to be related to the number of vortices and this number is a maximum when they are arranged in a close pattern as in the said small scale apparatus.

When, however, such apparatus is scaled-up to form part of a full-scale extraction plant the vortices tend to separate and to become elongated in the vertical direction, thus becoming fewer in number with consequent loss of efficiency.

According to the present invention fins or baffles are provided in the annular column space of apparatus of the type set forth for controlling the static vortex pattern without introducing a pumping action. In one successful arrangement annular fins are secured to an inner rotating cylinder at a spacing which is about twice their radial dimension, thus tending to confine between each pair of fins two oppositely rotating circular vortices.

An experimental column in accordance with the invention will now be described in detail by way of example. The column consists of an inner stainless steel cylinder or rotor suspended from a vertical shaft mounted in substantial bearings and arranged to be driven through reduction gearing by an electric motor so that the cylinder rotates slowly about its axis. The cylinder is $5\frac{1}{2}$ in. diameter and carries 18 annular fins spaced 1 in. apart and projecting $\frac{3}{4}$ in. from its surface.

The outer cylinder or stator is a cylindrical glass vessel $6\frac{1}{4}$ in. internal diameter and somewhat longer than the rotor. The bottom of the vessel is rounded and provided with an outlet at its lowest point for the aqueous raffinate. This non-cylindrical bottom part is "blanked-off" by a loose fitting and apertured polythene plug having a flat upper surface which is about 1 cm. below the bottom of the rotor.

Similarly a polythene plug with a flat apertured bottom surface "closes" the top of the vessel, the plug being split to fit around the shaft.

The aqueous feed is taken in to a point just above the upper plug from whence it is distributed into the column through the aperture in said plug. As stated above the aqueous raffinate is removed from the lowest point of the vessel. The solvent feed is taken from a manifold to four spaced points level with the bottom of the rotor and the solvent outlet is by suction from the highest part of the vessel.

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735,422 COMPLETE SPECIFICATION
1 SHEET

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